Doc.1

(12) UK Patent Application (19) GB (11) 2 295 296 (13) A

(43) Date of A Publication 22.05.1996

(21) Application No 9423950.6

(22) Date of Filing 18.11.1994

(51) INT CL[6]
H04B 7/185

(52) UK CL (Edition O)
H4L LDRR L1H10 L1H8A

(56) Documents Cited
EP 0536921 A1

(58) Field of Search
UK CL (Edition N) H4L LDRR LDRSX
INT CL[6] H04B 7/185
Online databases: WPI

(71) Applicant(s)
International Mobile Satellite Organization
99 City Road, LONDON, EC1Y 1AX, United Kingdom

(72) Inventor(s)
Jan de Baere

(74) Agent and/or Address for Service
R G C Jenkins & Co
26 Caxton Street, LONDON, SW1H 0RJ,
United Kingdom

(54) Mobile satellite communications system

(57) A communication system comprises: a plurality of earth stations arranged to communicate with mobile users via a plurality of satellites; a plurality of gateway stations for interconnecting terrestrial equipment with the earth stations; and a store for storing access data for said mobile terminals. The mobile terminals are divided into first and second categories, the store retaining corresponding different status information. First and second different communications channels between said gateway stations and said earth stations are provided and route control means selects one of said channels, in dependence upon the category of mobile terminal, using the system. Users required global roaming facilities are thereby connected via a dedicated network which may be entirely terrestrial while other users are connected via the PSTN. In this way an excessive number of satellite links required in a call is reduced for global roamers.

GB 2 295 296 A

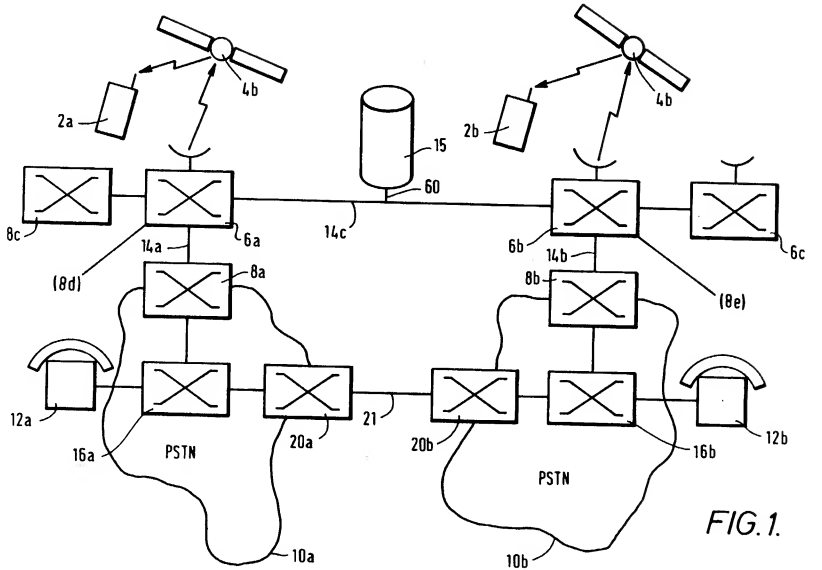
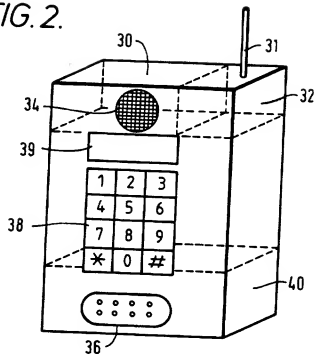

2a
4b
2b
4b
15
60
8c
6a
14c
6b
6c
14a
14b
(8d)
8a
8b
(8e)
12a
21
12b
16a
PSTN
20a
20b
16b
PSTN
10a
10b

FIG. 1.

FIG. 2.


30
31
34
32
39
1 2 3
4 5 6
38
7 8 9
* 0 #
40
36

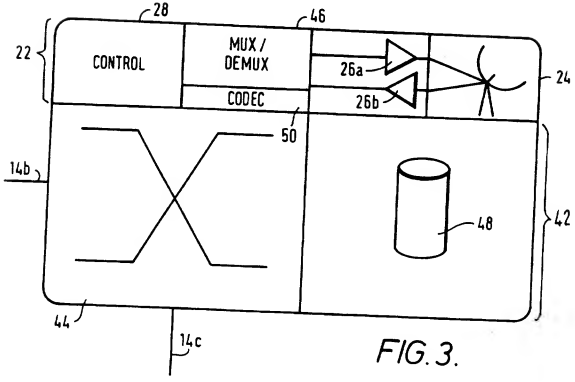

28
46
22
CONTROL
MUX / DEMUX
CODEC
26a
26b
24
50
14b
48
42
44
14c

FIG. 3.

FIG. 4.

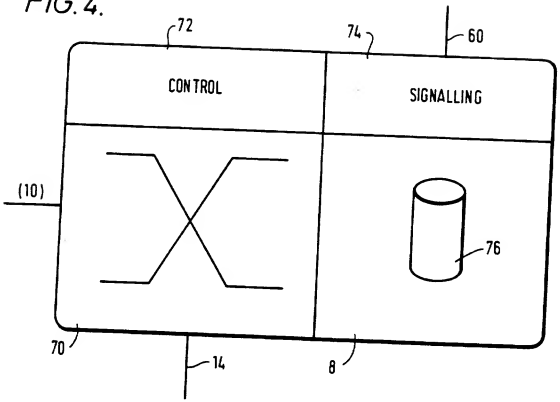

72
74
60
CONTROL
SIGNALLING
(10)
76
70
14
8

FIG. 5

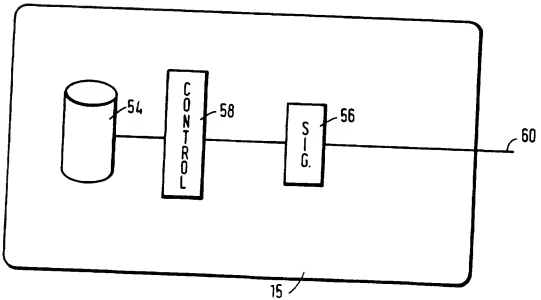

54
CONTROL
58
SIG.
56
60
15

FIG. 6.

54

ID #	STATUS	POSITION	ACTIVE NODE	AVAIL ?	HOME
00001	LOCAL	46°, 35°	6a	Y	8a

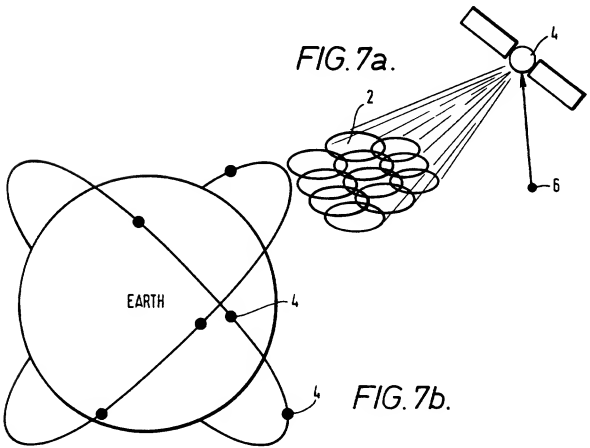


FIG. 7a.

FIG. 7b.

FIG. 8

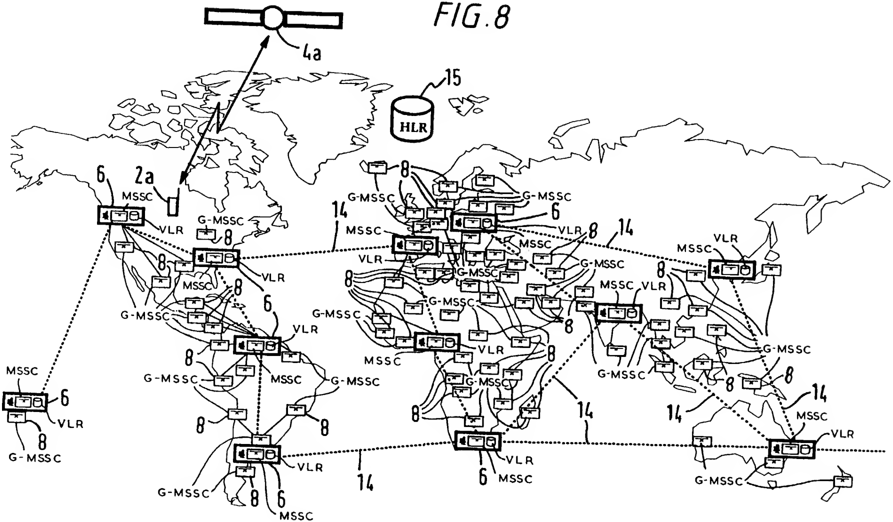


FIG. 9

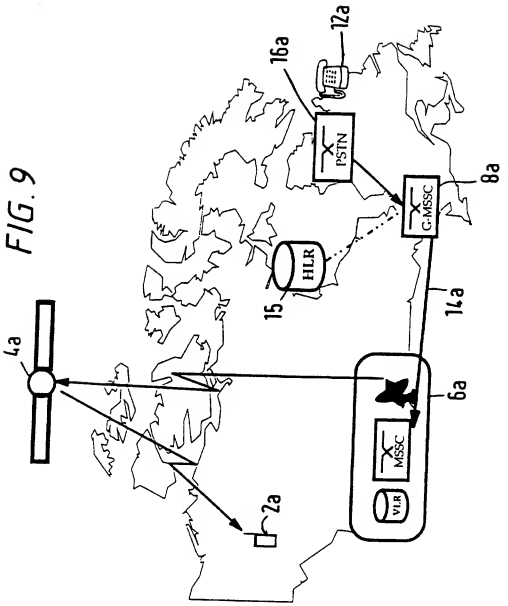


FIG. 10

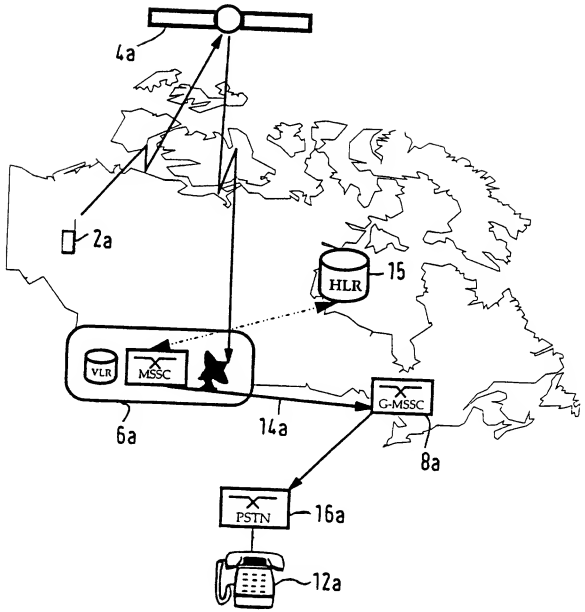


FIG. 11

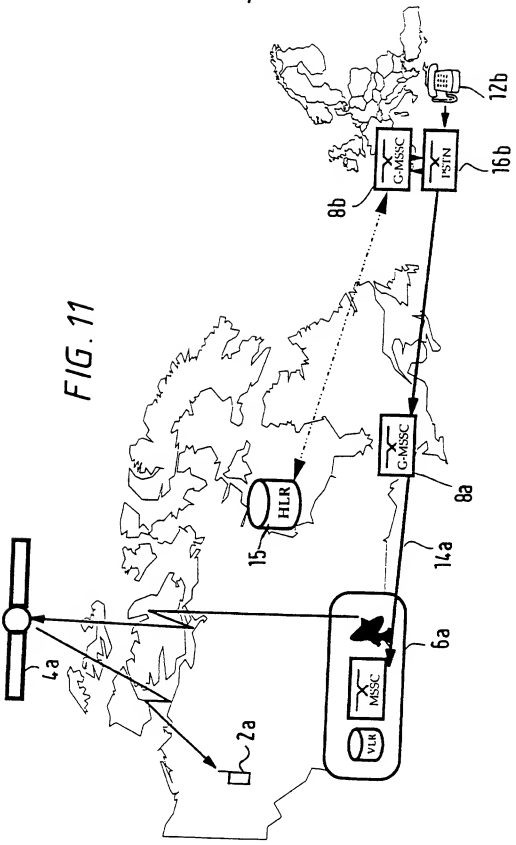


FIG. 12

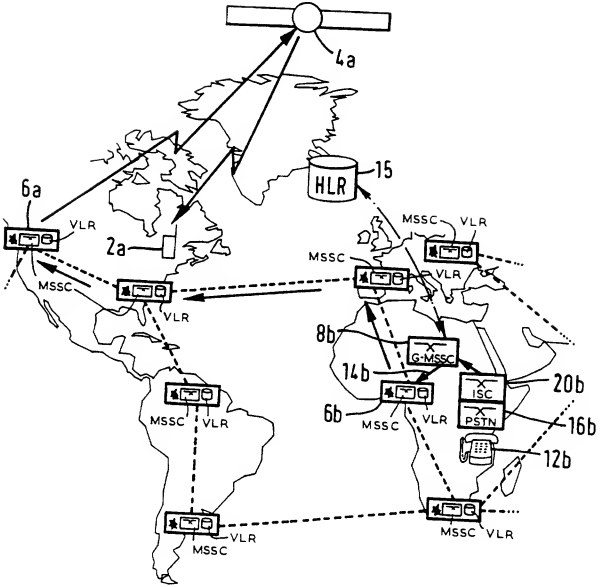
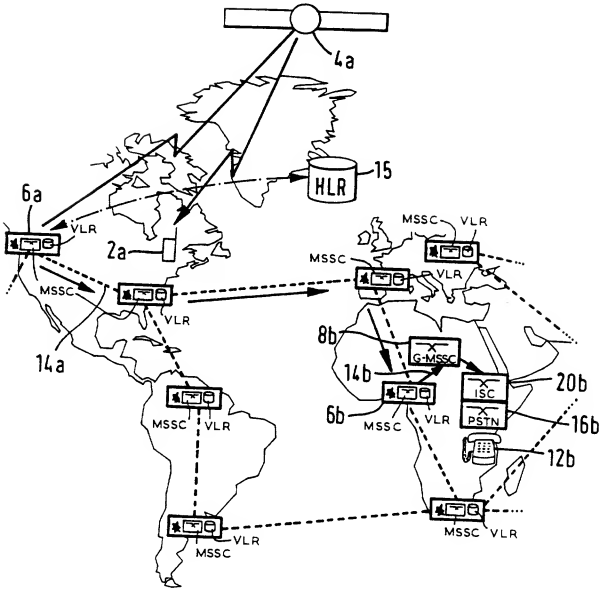

4a
HLR
15
6a
VLR
2a
MSSC
VLR
MSSC
VLR
MSSC
VLR
8b
G-MSSC
14b
6b
MSSC
VLR
ISC
PSTN
20b
16b
12b
MSSC
VLR
MSSC
VLR
MSSC
VLR

FIG. 13


4a
HLR
15
6a
VLR
2a
MSSC
VLR
14a
MSSC
VLR
MSSC
VLR
MSSC
VLR
8b
G-MSSC
14b
6b
MSSC
VLR
ISC
PSTN
20b
16b
12b
MSSC
VLR
MSSC
VLR

2295296

COMMUNICATIONS APPARATUS AND METHOD

FIELD OF THE INVENTION

This invention relates to communications with a mobile user, and in particular to such communications in which the link to the mobile user is via a satellite or satellites.

BACKGROUND ART

US 4189675 proposes a satellite communications method and apparatus for communicating with mobile users using a network of satellite in predetermined orbits. It would be possible to provide a complete communications network using only satellites, by utilising satellite-to-satellite links. However, both power and bandwidth are at a premium in satellite communications, and the capacity of such a network would therefore be small. It has therefore been proposed to employ ground components to form part of the link between one user and another.

A problem which arises is that of knowing where a mobile user is, in other words, to which satellite (and, with multi beam satellites, which beam) a call to that user should be directed. This problem is similar to that arising in the context of international terrestrial cellular radio systems, such as the GSM system. In that system, a register is maintained in a store of the locations of mobile

users.

EP 0562374 and EP 0568778 are believed to describe the call set up method used in the "Iridium" proposed satellite cellular mobile communication system. They describe a network in which information on the position of a mobile user is maintained at the ground switching office which is currently serving the mobile user, and also at a "home" station for each particular mobile subscriber. When a call is placed to a particular mobile subscriber, either the satellite switching office to which the call is first routed is the one currently serving the subscriber (in which case the call is placed directly via the satellite to the subscriber), or the switching office contacts the "home" station for the subscriber, and obtains the details of the current switching office serving the subscriber, to which the call is routed (although it is not clear in what manner the routing occurs).

An alternative description of the "Iridium" proposals is given in the paper "The Iridium (TM) system personal communications anytime, any place" J.E. Hatlelid and L. Casey, Proceedings of the Third International Mobile Satellite Conference IMC 93, 16-18 June 1993, pages 285-290, which reveals that it is proposed that the Iridium satellite cellular system is

intended to operate with terrestrial cellular radio, and that calls will be transmitted via a satellite only if terrestrial cellular communication is not available.

An alternative proposed satellite cellular system is described in "The Globalstar Mobile Satellite System for Worldwide Personal Communications", R.A. Weideman, pages 291-296 of the Conference Proceedings mentioned above. Two alternative access network schemes, invented by the author of that paper, and believed to have been proposed for use in the proposed Globalstar system, are described in EP 0536921 and EP 0506255. In the former of these, each mobile user is allocated a "home" gateway station, containing information on that user. Additionally, each gateway contains information on all mobile users currently in its area.

Calls are directed to the users home gateway station. If this is the gateway station within the area of which the user is currently located, the call is then routed to the mobile user by satellite. If not, the database held at the home gateway station is consulted and the call is re-routed from the home gateway to the active gateway within the area of which the mobile user is located. Details of the re-routing are not given; it is presumably via the public

network.

EP 0506255 is similar, but the user information and processing intelligence is located in the satellites, rather than in ground stations.

Both these latter two documents propose to use the satellite link only when a user has registered as "roaming" outside his normal area of operations; whilst inside this area, he is served by a terrestrial cellular communications network.

None of the foregoing publications take account of the technical problems which may arise when a satellite cellular communications system is used for connection to a roaming mobile user who may be located at one of a number of widely dispersed points on the Earth, and who may be called from a fixed telephone at any point across the earth via a public switched telephone network (PSTN).

To give an example, suppose that in the system described in EP 0536921, a mobile user has a home gateway in Australia, but is roaming in the United Kingdom (i.e. on a diametrically opposed point on the planet), and that he is called from a user in the UK. The call would first be routed through the international PSTN from the UK to Australia, to the home gateway, whence it would be re-routed by a further link back to an active gateway in or near the

UK, then finally relayed via the satellite to the mobile user. When it is borne in mind that each of the links between the UK and Australia may involve at least one satellite connection via, for example, satellites operated by INTELSAT, it will be seen that at least three "hops", each comprising an earth-satellite-earth round trip are involved. The total delay in the link thus can rapidly become very substantial, with consequent rapid degradation in the perceived quality of the connection. Further, other types of noise, distortion or echo degradation of the signal may also come into play.

SUMMARY OF THE INVENTION

The present invention provides a satellite mobile communications system in which a plurality of terrestrial gateways are interconnected by a dedicated terrestrial ground network; calls to mobile users in a category of users who are entitled to roam globally are routed through the dedicated network to the ground station serving the satellite currently serving the mobile user; and calls directed to a mobile user who is in a category of users not entitled to roam outside a limited geographical area are directed to the ground station serving that geographical area via another network (e.g. the PSTN on which the call arrived).

Thus, for mobile users who may genuinely be

located at dispersed locations over time, the call is routed via a dedicated, controlled network which may, for example, consist entirely of terrestrial links, so that the quality of the link to the earth station serving the satellite serving the mobile user can be controlled.

On the other hand, users who will not require global roaming (and whose position is therefore known) can be served predominantly through the PSTN, since a relatively direct and short route through the public switched telephone network can be set up.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram showing schematically the elements of a communications system embodying the present invention;

Figure 2 is a block diagram showing schematically the elements of mobile terminal equipment suitable for use with the present invention;

Figure 3 is a block diagram showing schematically the elements of an Earth station node forming part of the embodiment of Figure 1;

Figure 4 is a block diagram showing schematically the elements of a gateway station forming part of the

embodiment of Figure 1;

Figure 5 is a block diagram showing schematically the elements of a database station forming part of the embodiment of Figure 1;

Figure 6 illustrates the contents of a store forming part of the database station of Figure 5;

Figure 7a illustrates schematically the beams produced by a satellite in the embodiment of Figure 1;

Figure 7b illustrates schematically the disposition of satellites forming part of Figure 1 in orbits around the earth;

Figure 8 illustrates the geographical disposition of the components of Figure 1 on the Earth;

Figure 9 corresponds to a part of Figure 8 and shows the path taken by an incoming call to a locally registered mobile terminal;

Figure 10 corresponds to Figure 9 and shows the corresponding path taken by an outgoing call from the mobile terminal;

Figure 11 corresponds to Figure 9 and shows the path taken by an international incoming call to a locally registered mobile terminal;

Figure 12 corresponds to a part of Figure 8 and shows the path taken by an incoming call to a globally registered mobile terminal; and

Figure 13 corresponds to Figure 12 and shows the

corresponding path of an outgoing call from the mobile terminal.

PREFERRED EMBODIMENT

Referring to Figure 1, a satellite communications network according to this embodiment comprises mobile user terminal equipment 2a,2b; orbiting relay satellites 4a,4b; satellite earth station nodes 6a,6b; satellite system gateway stations 8a,8b; public switched telecommunications networks 10a,10b; and fixed telecommunications terminal equipment 12a,12b.

Interconnecting the satellite system gateways 8a,8b with the earth station nodes 6a,6b, and interconnecting the nodes 6a,6b with each other, is a dedicated ground-based network comprising channels 14a,14b,14c. The satellites 4, earth station nodes 6 and lines 14 make up the infrastructure of the satellite communications network, for communication with the mobile terminals 2, and accessible through the gateway stations 8.

A terminal location database station 15 is connected, via a signalling link 60 (e.g. within the channels 14 of the dedicated network) to the gateway station and earth stations 6.

The PSTNs 10a,10b comprise, typically, local exchanges 16a,16b to which the fixed terminal equipment 12a,12b is connected via local loops

18a,18b; and international switching centres 20a,20b connectable one to another via transnational links 21 (for example, satellite links or subsea optical fibre cable links). The PSTNs 10a,10b and fixed terminal equipment 12a,12b (e.g. telephone instruments) are well known and almost universally available today.

Each mobile terminal apparatus is in communication with a satellite 4 via a full duplex channel (in this embodiment) comprising a down link channel and an up link channel, for example (in each case) a TDMA time slot on a particular frequency allocated on initiation of a call, as disclosed in our earlier UK patent applications GB 94047669.2 (AGENTS REFERENCE J22422 GB) and GB 9414829.3 (AGENTS REFERENCE J22591 GB). The satellites 4 in this embodiment are non geostationary, and thus, periodically, there is hand over from one satellite 4 to another.

Mobile terminal 2

Referring to Figure 2, the mobile terminal equipment of Figure 1 is shown.

One suitable form is a handset, as shown. Details of the handsets 2a,2b etc do not form part of the present invention, but they may comprise handsets similar to those presently available for use with the GSM system, comprising a digital coder/decoder (CODEC)

30, together with conventional microphone 36, loudspeaker 34, battery 40 and keypad components 38, and a radio frequency (RF) interface 32 and antenna 31 suitable for satellite communications. Preferably a display 39 (for example a liquid crystal display) is also provided. A 'smart card' reader receiving a smart card storing user information may be present.

Earth Station Node 6

The earth station nodes 6 are arranged for communication with the satellites.

Each earth station node 6 comprises, as shown in Figure 3, a conventional satellite earth station 22 consisting of at least one satellite tracking antenna 24 arranged to track at least one moving satellite 4, RF power amplifiers 26a for supplying a signal to the antenna 24, and 26b for receiving a signal from the antenna 24; and a control unit 28 for storing the satellite ephemera data, controlling the steering of the antenna 24, and effecting any control of the satellite 4 that may be required (by signalling via the antenna 24 to the satellite 4).

The earth station node 6 further comprises a mobile satellite switching centre 42 comprising a network switch 44 connected to the trunk links 14 forming part of the dedicated network. A multiplexer 46 is arranged to receive switched calls from the

switch 44 and multiplex them into a composite signal for supply to the amplifier 26 via a low bit-rate voice codec 50. Finally, the earth station node 6 comprises a local store 48 storing details of each mobile terminal equipment 2a within the area served by the satellite 4 with which the nodes 6 is in communication.

Gateway 8

Referring to Figure 4, the gateway stations 8a,8b are, in this embodiment, commercially available mobile switch centres (MSCs) of the type used in digital mobile cellular radio systems such as GSM systems. They could alternatively comprise a part of an international or other exchange forming one of the PSTNs 10a,10b operating under software control to interconnect the networks 10 with the satellite system trunk lines 14.

The gateway stations 8 comprise a switch 70 arranged to interconnect incoming PSTN lines from the PSTN 10 with dedicated service lines 14 connected to one or more Earth station nodes 6, under control of a control unit 72. The control unit 72 is capable of communicating with the data channel 60 connected to the database station 15 via a signalling unit 74, and is arranged to generate data messages in some suitable format (e.g. as packets or ATM cells).

Also provided in the gateway stations 8 is a store 76 storing billing, service and other information relating to those mobile terminals 2 for which the gateway station 8 is the home gateway station. Data is written to the store 76 by the control unit 72 after being received via the signalling unit 74 or switch 70, from the PSTN 10 or the Earth station nodes 6 making up the satellite network.

The satellite system trunk lines 14 comprise, in this embodiment, high quality leased lines meeting acceptable minimum criteria for signal degradation and delay. In this embodiment, all the lines 14 comprise terrestrial links. The trunk lines 14 are preferably dedicated lines, so that the lines 14 form a separate set of physical channels to the networks 10. However, the use of virtual circuits through the networks 10 is not excluded.

Location Database Station 15

Referring to Figure 5 the global database station 15 comprises a digital data store 54, a signalling circuit 56, a processor 58 interconnected with the signalling circuit 56 and the store 54, and a signalling link 60 interconnecting the database station 15 with the gateway stations 8 and Earth stations 6 making up satellite system network, for

signalling or data message communications.

The store 54 contains, for every subscriber terminal apparatus 2, a record showing the current status of the terminal 2 (whether it is "local" or "global" as will be disclosed in greater detail below); the geographical position of the mobile terminal 2 (either in co-ordinate geometry, or as code identifying an area within which it lies); the "home" gateway station 8 with which the apparatus is registered (to enable billing and other data to be collected at a single point) and the currently active Earth station node 6 with which the apparatus 2 is in communication via the satellite 4. The contents of the store are indicated in Figure 6.

The signalling unit 56 and processor are arranged to receive interrogating data messages, via the signalling circuit 60 (which may be a packet switched connection), from gateways 8 or nodes 6, comprising data identifying one of the mobile terminals 2 (for example, the telephone number of the equipment 2), and the processor 58 is arranged to search the store 54 for the status and active earth station node 6 of the terminal 2 and to transmit these in a reply message via the data line 60.

Satellites 4

The satellites 4a,4b comprise generally

conventional communications satellites, and may be as disclosed in our earlier filed UK application 94047669.2 (AGENTS REFERENCE J24222 GB). Each satellite 4 is arranged to generate an array of beams covering a footprint beneath the satellite, each beam including a number of different frequency channels and time slots, as described in our earlier UK application GB 9414829.3 (AGENTS REFERENCE J22591 GB) and illustrated in Figure 7a.

The satellites 4a are arranged in a constellation in sufficient numbers and suitable orbits to cover a substantial area of the globe (preferably to give global coverage) for example 10 (or more) satellites may be provided in two (or more) mutually orthogonal intermediate circular orbits at an altitude of, for example, 10,500 kilometres as shown in Figure 7b. Equally, however, larger numbers of lower satellites may be used, as disclosed in EP 0365885, or other publications relating to the Iridium system, for example.

Geographical arrangement

Referring to Figure 8, one exemplary geographical arrangement is shown (only one satellite 4a is shown for clarity). The database station 15 may be located anywhere, and the position indicated is purely notional; in practice, it is preferably located in the

geographical area from which most calls originate, or within which the best signalling infrastructure exists. In Figures 8 onwards, a dotted line denotes a signalling link and a solid line denotes a communications traffic link.

With the number of satellites mentioned below, there may typically be 12 earth station nodes 6, two for each continent. In this manner, each earth station node 6 is connectable to gateways 8 on the continent, whilst having in view one or more satellites 4.

In this embodiment there are significantly larger number of gateways 8 than of earth station nodes 6; on the order of one per country (i.e. over a hundred in total). For larger countries, several gateways 8 may be provided at different geographical locations, or (where several network operators are permitted in the country) one per PSTN. Smaller countries may share gateways 8. Gateways 8 may also be provided from terrestrial cellular networks (although this is not explicitly indicated in Figure 8).

For ease of explanation PSTNs 10 are omitted from Figure 8 since their coverage is virtually global.

The operation of the above embodiment will now be described in greater detail.

Registration and Location

In the present embodiment, as mentioned above, a customer mobile terminal apparatus 2 may be registered with one of two distinct statuses; "local" in which the mobile terminal apparatus is permitted only to communicate through one local area, or part of the satellite system network, and "global", which entitles the apparatus to communicate through any part of the satellite system network. Since the latter option places a greater demand on network resources (as will be discussed below), a higher charge may be made for calls for customers registered as "global" or "roaming" users.

The status of each apparatus 2 (i.e. "local" or "global") is stored in the record held for the apparatus 2 concerned in the store 54 of the database station 15, either as a result of a manual input via a keyboard to the store acting on the expressed preference of the owner of the apparatus 2, or (as will be discussed below) in response to a signal from the apparatus 2 requesting a status change.

The mobile terminal apparatus 2 performs an automatic registration process, of the kind well known in the art of cellular terrestrial communications, on each occasion when the terminal 2 is utilised for an outgoing call; and/or when the apparatus 2 is switched on; and/or periodically whilst the apparatus 2 is

switched on. As is conventional, the registration process takes the form of the broadcasting of a signal identifying the mobile terminal 2 (e.g. by transmitting its telephone number on a common hailing or signalling frequency).

The transmitted signal is picked up by one or more satellites 4. Under normal circumstances, the signal is picked up by multiple satellites 4, and the received signal strength and/or time of arrival are transmitted, together with the identity of the mobile apparatus 2 and of the satellite 4 receiving the signal, to the database station 15 via the earth stations node or nodes 6 for which the satellites 4 are in communications, and the signalling line 60.

The processor 58 of the database station 15 then calculates, e.g. on the basis of the differential arrival times, the terrestrial position of the mobile terminal apparatus 2, which is stored in the database 54. Also stored is the identity of the earth station node 6 most suitable for communicating with the mobile terminal apparatus 2 (the "active" station). This is typically found by the processor 58 comparing the stored position of the terminal 2 with the predetermined stored positions of each of the earth station nodes 6 and selecting the nearest. However, account may also or instead be taken of the strength

of the signals received via the satellites 4, or of other factors (such as network congestion) to result, in borderline cases, in the choice of a node earth station which is not geographically closest to the mobile terminal equipment 2. The identity of the allocated active earth station node 6 is then likewise stored in the store 54 in the record for that terminal apparatus.

LOCAL STATUS

The stored status of the mobile terminal equipment 2 is read by the processor 58. If the status is "local", the stored position of the mobile terminal apparatus is compared with the local range permitted to the user (for example, the national boundaries of a country or a PSTN 10). In a simple example according to this embodiment, the local area is a geographical area covered by a PSTN 10 connected to the home gateway station of the mobile terminal 2.

If the position of the terminal equipment 2 lies outside the local area within which it is permitted to communicate, an "out-of area" flag is set in the record in the store 54 relating to the user. A message is transmitted by the processor 58 (via the signalling circuit 56 and signalling line 60) to the active earth station node 6 to which the mobile terminal apparatus 2 has been allocated, comprising

the identity of the mobile terminal unit 2, together with its geographical position, an indication that it is registered as a local user, an indication of its "home" gateway, and a flag indicating that it is unavailable as being out of its area. This data is stored in a record created for the mobile terminal equipments in the store 48 within the earth station node 6.

The active earth station node 6 will take no further action to connect either incoming or outgoing calls with the mobile apparatus 2. It may send an "out of area" message via the satellite 4 to the mobile apparatus 2, comprising the identification code for the mobile and an "out of area" code, in response to which the mobile terminal apparatus 2 may display a message on the display 39, or otherwise indicate the "out of area" status to a user (for example, by generating a audio tone through the loudspeaker 34 or illuminating an indicator lamp).

In the event that the processor 58 determines that the mobile terminal equipment 2 is registered as "local" and is within its permitted local area, a message is transmitted to the active allocated earth station node 6 indicating the same details of identity, position and local status, but setting an "available" flag rather than an "out of area" flag as

previously. In this instance, the earth station node 6 will in future treat the mobile terminal apparatus 2 as being available for communications, by allocating a communications channel and satellite to the apparatus on initiation of either an incoming or an outgoing call.

GLOBAL STATUS

If the processor 58 identifies, from the record in the store 54, that the status of the registering mobile terminal apparatus is "global", it transmits, via the signalling circuit and signalling line 60, a message (which, as above, contains the terminal identification number, status ("global"), position, and home gateway identification for the mobile terminal apparatus 2) to the allocated active earth station node 6, which creates or updates a record in its store 48.

Thus, as a result of the registration process described, a central record for every mobile terminal apparatus 2 is maintained in the store 54 of the database station 15 accessible by nodes 6 and gateways 8; and each node 6 maintains in its store 48 a local record of every mobile communications apparatus 2 within its area, together with its position and home gateway, and available or unavailable status.

It would also be possible for the stores 48 of

each node 6 to store only data relating to global status and local - in-area status apparatus, and not store data relating to local status mobile terminal 2 which are out of their own area.

The store 54 acts somewhat in the manner of the Home Location Register (HLR) of a GSM terrestrial cellular system, and the store 48 in the manner of the Visiting Location Register (VLR) of GSM; commercially available HLR and/or VLR equipment may therefore be employed for these components, modified as necessary.

CHANGE OF STATUS

The operator of a given mobile terminal apparatus 2 may change the status thereof between "local" and "global" or vice versa, either by communicating with the operator of the satellite system network and thereby causing a manual data entry into the contents of the store 54, or by initiating a sequence of key strokes on the key pad 38, or otherwise, inputting a signal to the mobile terminal apparatus 2.

In the former case, the change of status is signalled by the processor 58 to the allocated active node 6, which updates the record within its store 48, and in the later case the sequence of key strokes received from the mobile terminal equipment 2 is relayed via the satellite 4 to the active node 6, which transmits the change of status as a signal to

the database station 15, at which the processor 58 updates the record stored in the store 54 and signals back for the active node 6 to do likewise within its store 48. It is preferred that handshaking techniques of this type be employed, to ensure that the records stored in the central store 54 and stores 48 in node stations 6 be kept in agreement.

Although it is not germane to the present invention, it will be apparent that the stores 54 or 48 may store other information pertaining to the customer or apparatus 2, and that all information stored in the store may be updated by manual entry or signalling from other sources (for example, position location apparatus within mobile terminal equipment 2 where available, using e.g. the Global Positioning System (GPS)). Any change in information stored in relation to the customer or the equipment 2 is relayed to the central database station 15 in the form of a message via the signalling link 60, and is distributed therefrom to the active node 6.

In particular, further information is held at the "home" gateway 8, comprising at least billing records for usage of the satellite system network by the mobile terminal apparatus 2.

CALL SET UP AND ROUTING

The processes of routing calls to and from mobile

terminal apparatus 2 in the present invention will now be described. By way of example, calls to and from fixed stations 12 available through PSTN networks are described, but it will be immediately apparent that the same principles are applicable to communication to and from terrestrial mobile terminals available through public land mobile networks (PLMNs).

1. LOCAL USER - LOCAL CALL

A. Fixed to mobile calls

First, the case where the mobile terminal equipment 2 is registered as a "local" user will be considered with reference to Figure 9.

The terminal apparatus 2a, being registered as "local" to the nearest gateway 8a, has a dial number which is recognised by the PSTN 10a to which the gateway 8a is connected as relating to the satellite service network.

The fixed terminal 12a dials through the local PSTN node 16a, and the call is routed via the PSTN 10a to the local gateway 8a. The gateway 8a sends an interrogation message to the database station 15, comprising the dial number of the mobile terminal equipment 2a. The database station 15 transmits back, in reply, the information that the terminal equipment 2a is registered as local and is available (i.e. is currently in the local area of the gateway 8a), and,

in this embodiment, the identification of the node 6a via which the mobile terminal equipment 2a is contactable.

The gateway 8a sets up a connection, via ground network line 14a, to the ground station node 6a, passing on the dial number of the mobile terminal equipment 2a to be called. The earth station node 6a switches the call into the appropriate multiplexed time/frequency channel within the up link broadcast to the satellite 4a (and, preferably, at least one further satellite 4b, as disclosed in our earlier application GB 9414829.3 (AGENTS REFERENCE J22591 GB)).

The satellite 4a demultiplexes the up link signal and routes the call to a time/frequency slot on one of its beams, via which it is broadcast to the mobile terminal equipment 2a. A corresponding return link from the mobile station 2a is set up, and the channel is held open during the duration of the call. The earth station node 6a then transmits billing information to the local (home) gateway 8a, for subsequent billing of the mobile terminal 2a.

B Mobile to fixed call

When a locally registered mobile terminal 2a, which is within its permitted area, wishes to initiate an outgoing call to a fixed station 12b, as shown in

Figure 10, the terminal 2a transmits a message to the ground station node 6a via the satellite 4a including the dial number of the fixed terminal 12a.

The earth station node 6a transmits an interrogation message to the database station 15, to determine the home gateway 8a with which the mobile terminal equipment 2a is registered, and sets up a call to the home gateway 8a via the ground network line 14a, through which the dial number of the fixed terminal 12a is transmitted. The gateway 8a passes the dial number to the local PSTN 10a to which it is connected, and the call is thereby set up.

The circuit through the line 14 and PSTN 10a is maintained during the duration of the call. After completion of the call, the earth station node 6a transmits billing information to the home gateway 8a as above.

2. LOCAL USER - INTERNATIONAL CALL

A Fixed to mobile call

Referring to Figure 11, a fixed terminal 12b in a different country dials, as before, the dial number of a mobile terminal 2a. The local exchange 16b and PSTN 10b recognise the prefix as being a call to the international satellite network and route the call to the local gateway station 8b connected to the PSTN 10b.

The gateway 8b transmits an interrogation signal to the database station 15 including the dial number of the called mobile terminal 2a. In reply, the database station 15 returns the information that the mobile terminal 2a is registered as a local terminal, and supplies the dial number of the home gateway 8a of the mobile terminal 2a.

The gateway 8b holds open the connection from the PSTN 10a, and sets up a return connection to the PSTN 10a through which the dial number of the home gateway 8a is supplied. The dial number is recognised as an international call by the PSTN 10b and is routed, via international switching centres 20b,20a and transnational link 21, to the home gateway 8a, which sets up a connection, via dedicated line 14a, to the earth station node 6a to which it is connected and, as before, the call is connected to the mobile terminal 2a via the satellite 4.

Thus, in this embodiment, when a call from a local user originates from a different area (for example a different country), the call is initially directed to the local satellite system gateway 8a, which then determines the home gateway of the mobile user and directs the call on through the international public switched telephone network (PSTN).

B Mobile to fixed call

The process here is identical to that described in relation to Figure 10, since the dial number supplied to the home gateway 8a contains the international dialling prefix necessary to set up the call to the remote PSTN 10b and called terminal 12b; the first PSTN 10a to which the gateway is connected will dial through as appropriate in accordance with the dial number supplied by the mobile terminal 2a.

3. OUT OF AREA LOCAL USER

As described above, if a locally registered terminal 2 is out of its area it will receive no service. In the event of an incoming call, as described in relation to Figures 9 or 11, when the database station 15 is interrogated, the reply signal will indicate that the status of the terminal equipment 2 is unavailable, and the call will be terminated without it having been necessary to set up an international call. When the mobile terminal 2 attempts to initiate an outgoing call, it will be unsuccessful.

4. GLOBAL USER

A Fixed to mobile call

Referring to Figure 12, the initial steps in this process are as in the preceding cases. The fixed terminal 12b dials the dial number of the mobile terminal 2a. The local PSTN 10b recognises it as

pertaining to the satellite service network and routes the call to the local gateway 8b. For example, the call number of the mobile terminal 2a may be prefixed by an international dialling code, such that the call is routed through the PSTN 10b to the international switch centre 20b thereof, from whence it is routed to the gateway 8b.

At the gateway 8b, the gateway station transmits an interrogation message to the database station 15 including the call number or identification of the called mobile terminal 2a. The database station 15 replies with a message which specifies the global status of the mobile terminal 2a, and comprises an identification of the earth station node 6a via which the mobile terminal 2a may be contacted.

The gateway 8b then sets up a connection via dedicated line 14b to the active earth station node 6a, via its local node station 6b, through the dedicated ground network lines 14. The active node station 6a then sets up the link to the mobile terminal equipment 2a via the satellite 4a as discussed above.

After completion of the call, the active earth station unit transmits billing data to the home gateway for the mobile user 2a.

Thus, it will be seen that in this embodiment, in

routing a call to a global rather than a local user, the gateway 8 at which the call first arrives is arranged to route the call to the active earth station node via the dedicated ground network lines 14, rather than via the PSTN as for a local user.

In this case, the home gateway of the mobile terminal equipment 2a plays no part in the routing process; this is technically desirable, since the home gateway might be at a point on the planet distant from either the calling terminal 12b or the active earth station node 6a. Instead, the route from the calling gateway 8b (which is generally geographical close to the calling terminal 12b) to the active earth station node 6a via the dedicated ground network lines 14 is chosen to be relatively direct, and to utilise dedicated lines 14 of a quality which will not, when in combination with the satellite link via the satellite 4, render the link unacceptable to a user.

B Mobile to fixed call

Referring to Figure 13, when a mobile terminal 2a attempts to originate an outgoing call to a fixed terminal 12b, it initiates a call via the satellite 4a to the earth station node 6a, commencing by signalling the dial number of the fixed terminal 12b (including country code).

The earth station node 6a determines, from the

country code dialled, the gateway 8b which is connected to (or is closest to) the PSTN 10b to which the fixed terminal 12b is connected, and sets up a circuit through the dedicated lines 14 forming the ground network to that gateway 8b via the earth station node 6b to which it is connected.

The target gateway 8b passes the remainder (excluding country code) of the dialled call number of the fixed terminal 12b to the PSTN 10b via the international switch centre 20b thereof and the call is routed to the fixed terminal 12b, the circuit being held open for the duration of the call.

On termination of the call, the active node 6a transmits billing data to the home gateway of the mobile terminal apparatus 2a as before.

Thus, it will be seen that in this case also, the call proceeds via the dedicated ground network 14 rather than via the international PSTN lines 21 (as was the case for the local registered user above), enabling a better and relatively direct connection which does not involve the home gateway of the mobile terminal 2a (which could be located distant from the mobile terminal or the fixed terminal).

MOBILE-TO-MOBILE CALLS

A mobile-to-mobile calls is executed simply as a mobile-to-fixed call (described above), followed by a

fixed-to-mobile call (as described above). Thus, a call between two global users is routed entirely over the ground network between the calling and called active earth station nodes, as are calls from a global to a local mobile and vice-versa. A call from one local user to another, on the other hand, is routed predominantly through the PSTN.

LOCAL CALL NUMBERING

In the above-described embodiments the dial numbers allocated to mobile users have 'international' prefixes followed by a code which does not correspond to any national PSTN but does correspond to the satellite service network.

It is equally possible, however, to provide an embodiment in which such numbers do have a prefix code which corresponds to a particular PSTN or PLMN. In this embodiment, the description is modified in the following respects. The local gateways 8a etc. are connected to a local exchange of the PSTN. When a fixed user dials a mobile user, the call is routed through the PSTN, either to the local exchange (if within the same PSTN as the fixed user) or through the ISC of the PSTN, via an international circuit, to a distant PSTN within which the local exchange is located.

At the local exchange, the dial number is

recognised as belonging to the satellite mobile system and a call is set up to the local gateway 8a. From this point on, the process is as described above, the call being selectively routed either via the dedicated ground network or the PSTN (or PLMN or other network).

OTHER EMBODIMENTS

It will be clear from the foregoing that the above described embodiment is merely one way of putting the invention into effect. Many other alternatives will be apparent to the skilled person and are within the scope of the present invention.

For example, the numbers of satellites and satellite orbits indicated are purely exemplary. Smaller numbers of geostationary satellites, or satellites in higher altitude orbits, could be used; or larger numbers of low earth orbit (LEO) satellites could be used. Equally, different numbers of satellites in intermediate orbits could be used.

Although TDMA has been mentioned as suitable access protocol, the present invention is fully applicable to other access protocols, such as code division multiple access (CDMA) or frequency division multiple access (FDMA).

Equally, whilst the principles of the present invention are envisaged above as being applied to satellite communication systems, the possibility of

the extension of the invention to other communications systems is not excluded.

Although, for the sake of convenience, the term "mobile" has been used in the foregoing description to denote the terminals 2, it should be understood that this term is not restricted to handheld or hand-portable terminals, but includes, for example, terminals to be mounted on marine vessels or aircraft, or in terrestrial vehicles. Equally, it is possible to practice the invention with some of the terminals 2 being completely immobile.

Instead of providing a single central database station 15 storing details of all terminal equipment 2, similar details could be stored at the home gateway 8 for all terminal equipment to register with that home gateway 8.

To reduce traffic volumes on the ground network, it would be possible to put the low bit-rate codecs at the gateways 8, so that all traffic within the satellite system is encoded, being coded on entry into and decoded on exit from the system.

In the transmission of billing data, the billing data may either be actual cost or charge data, or duration data.

In the foregoing, the gateways 8 may in fact be comprised within an ISC or exchange or mobile

switching centre (MSC) by providing additional operating control programmes performing the function of the gateway.

In the foregoing, dedicated ground networks lines have been described, and are preferred. However, use of PSTN or PLMN links is not excluded where, for example, leased lines are unavailable or where temporary additional capacity is required to cope with traffic conditions.

It will naturally be clear that the stores within the gateways 8 need not be physically co-located with other components thereof, provided they are connected via a signalling link.

Whilst, in the foregoing, the term "global" is used, and it is preferred that the satellite system should cover all or a substantial part of the globe, the invention extends also to similar systems with more restricted coverage (for example of one or more continents).

It will be understood that the geographical locations of the various components of the invention are not important, and that different parts of the system of the above embodiments may be provided in different national jurisdictions. For the avoidance of doubt, the present invention extends to any part or component of telecommunications apparatus or systems

which contributes to the inventive concept of selectively defining local and global system users, and treating the two differently.

The foregoing, and all other variants, embodiments, modifications or improvements to the invention are intended to be comprised within the present invention.

CLAIMS

1. A communication system for communication with a plurality of mobile terminals, the system comprising:

a plurality of orbiting satellites;

a plurality of earth stations arranged to communicate with the mobile users via the satellites;

a plurality of gateway stations for interconnecting terrestrial equipment with the earth stations; and

a store for storing access data for said mobile terminals;

characterised in that;

the mobile terminals are divided into first and second categories, the store retaining corresponding different status information, both said first and second categories communicating with said satellites, and in that there are provided;

first and second different communications channels between said gateway stations and said earth stations, and in that there are provided;

route control means for selecting one of said first and second channels, in dependence upon the category of a mobile terminal.

2. A system according to claim 1, in which said first category is a local category associated with a limited permitted geographical range of said mobile terminal.

3. A system according to claim 1, in which said first category is a local category defining a limited permitted part of said system with which said mobile terminal may communicate.

4. A system according to claim 1, in which said second category is a global category specifying that said mobile terminal may communicate with any part of said system.

5. A system according to claim 1, in which said first communication channel comprises a dedicated ground network interconnecting said earth stations and said gateway stations.

6. A system according to claim 5, in which said ground network comprises leased lines.

7. A system according to claim 5 or claim 6, in which said ground network comprises virtual circuits provided over shared lines.

8. A system according to claim 5, 6 or 7 in which said ground network comprises terrestrial lines in preference to satellite links.

9. A system according to claim 5, in which said ground network comprises trunk connections between said earth stations, and there are provided routing switches at said earth stations, and further comprises spur links from the earth stations to the gateway stations.

10. A system according to claim 1, in which said second channel comprises an international public switched network link.

11. A system according to claim 1, in which said store is provided at one or more central storage stations, communicating with said earth stations and/or said gateway stations via a signalling channel.

12. A system according to claim 1, in which said store is arranged to store, for the mobile terminals, position information specifying the position of the mobile terminals.

13. A system according to claim 1, in which said

gateway stations are associated with terminal home stores, and said mobile terminals are each assigned to a said home store.

14. A system according to claim 13, in which said home stores are arranged to store billing data for mobile terminals assigned thereto.

15. A system according to claim 14, in which said billing data represents a different charge for said mobile terminals of said first category to that of mobile terminals of said second category.

16. A system according to claim 1, further comprising means for altering the category of a mobile terminal, and for changing the status information held in the store correspondingly.

17. Satellite system routing equipment for interconnecting a mobile terminal satellite communications system with a terrestrial communications link, said equipment comprising routing means for selectively interconnecting said communications link with one of first and second communications channels, either of said channels connecting to said mobile terminal via a

communications satellite and an earth station, depending upon whether said mobile terminal falls into first or second predetermined categories.

18. Equipment according to claim 17, further comprising a terminal home store for storing billing data for a plurality of mobile terminals associated with the home store.

19. Equipment according to claim 18, further comprising means for receiving billing data from said mobile terminal satellite communications system and for updating said home store.

20. Equipment according to claim 17, in which said communications link comprises a telecommunications network, said equipment comprising a gateway between said telecommunications network and said mobile terminal satellite communications system, and said second communications channel comprises the same telecommunications network.

21. Satellite system routing equipment for interconnecting a mobile terminal, communicating via a satellite link with said equipment, with a called terminal, the equipment comprising routing means for

selectively interconnecting said satellite link with one of first and second communications channels, either of said channels connecting to said called terminal , depending upon whether said mobile terminal falls into first or second predetermined categories.

22. Equipment according to claim 21, in which the routing means comprises an exchange for interconnecting portions of said first channel.

23. Equipment according to claim 21, further comprising a satellite earth station.

24. Equipment according to claim 17 or claim 21, further comprising a signalling circuit for signalling a routing request signal, indicating the identity of a mobile terminal called on said communications link, to a store and for receiving a reply signal, said equipment selecting either said first or said second channel in dependence upon said reply signal.

25. Equipment according to claim 17 or claim 21, in which said first communication channel comprises a dedicated ground network interconnecting said earth station and said gateway equipment.

26. Equipment according to claim 25, in which said ground network comprises a leased line.

27. Equipment according to claim 25, in which said ground network comprises a virtual circuit provided over a shared line.

28. Equipment according to claim 17 or claim 21, in which said second communications channel comprises an international public switched network.

29. A method of connecting a mobile terminal, via a satellite and a satellite earth station, with a terrestrial communications link, comprising selecting one of two alternative routes between the earth station and the communications link depending on whether the mobile terminal is of first or second status.

30. A method of connecting a mobile terminal, via a satellite and a satellite earth station, with a terrestrial communications link, comprising setting up a route through a terrestrial long-distance network between the earth station and the communications link, and ensuring that, where possible, said route excludes satellite links.

31. A satellite mobile communications system which defines user local areas, and devices access to a user outside his area.

Amendments to the claims have been filed as follows

1. A communication system for communication with a plurality of mobile terminals, the system comprising:

a plurality of orbiting satellites;

a plurality of earth stations arranged to communicate with the mobile users via the satellites;

a plurality of gateway stations for interconnecting terrestrial equipment with the earth stations; and

a store for storing access data for said mobile terminals;

characterised in that;

the mobile terminals are divided into first and second categories, the store retaining corresponding different status information, both said first and second categories communicating with said satellites, and in that there are provided;

first and second different communications channels between said gateway stations and said earth stations, and in that there are provided;

route control means for selecting one of said first and second channels, in dependence upon the category of a mobile terminal.

2. A system according to claim 1, in which said first category is a local category associated with a limited permitted geographical range of said mobile terminal.

3. A system according to claim 1, in which said first category is a local category defining a limited permitted part of said system with which said mobile terminal may communicate.

4. A system according to claim 1, in which said second category is a global category specifying that said mobile terminal may communicate with any part of said system.

5. A system according to claim 1, in which said first communication channel comprises a dedicated ground network interconnecting said earth stations and said gateway stations.

6. A system according to claim 5, in which said ground network comprises leased lines.

7. A system according to claim 5 or claim 6, in which said ground network comprises virtual circuits provided over shared lines.

8. A system according to claim 5, 6 or 7 in which said ground network comprises terrestrial lines in preference to satellite links.

9. A system according to claim 5, in which said ground network comprises trunk connections between said earth stations, and there are provided routing switches at said earth stations, and further comprises spur links from the earth stations to the gateway stations.

10. A system according to claim 1, in which said second channel comprises an international public switched network link.

11. A system according to claim 1, in which said store is provided at one or more central storage stations, communicating with said earth stations and/or said gateway stations via a signalling channel.

12. A system according to claim 1, in which said store is arranged to store, for the mobile terminals, position information specifying the position of the mobile terminals.

13. A system according to claim 1, in which said

gateway stations are associated with terminal home stores, and said mobile terminals are each assigned to a said home store.

14. A system according to claim 13, in which said home stores are arranged to store billing data for mobile terminals assigned thereto.

15. A system according to claim 14, in which said billing data represents a different charge for said mobile terminals of said first category to that of mobile terminals of said second category.

16. A system according to claim 1, further comprising means for altering the category of a mobile terminal, and for changing the status information held in the store correspondingly.

17. Satellite system routing equipment for interconnecting a mobile terminal satellite communications system with a terrestrial communications link, said equipment comprising routing means for selectively interconnecting said communications link with one of first and second communications channels, either of said channels connecting to said mobile terminal via a

communications satellite and an earth station, depending upon whether said mobile terminal falls into first or second predetermined categories.

18. Equipment according to claim 17, further comprising a terminal home store for storing billing data for a plurality of mobile terminals associated with the home store.

19. Equipment according to claim 18, further comprising means for receiving billing data from said mobile terminal satellite communications system and for updating said home store.

20. Equipment according to claim 17, in which said communications link comprises a telecommunications network, said equipment comprising a gateway between said telecommunications network and said mobile terminal satellite communications system, and said second communications channel comprises the same telecommunications network.

21. Satellite system routing equipment for interconnecting a mobile terminal, communicating via a satellite link with said equipment, with a called terminal, the equipment comprising routing means for

selectively interconnecting said satellite link with one of first and second communications channels, either of said channels connecting to said called terminal , depending upon whether said mobile terminal falls into first or second predetermined categories.

22. Equipment according to claim 21, in which the routing means comprises an exchange for interconnecting portions of said first channel.

23. Equipment according to claim 21, further comprising a satellite earth station.

24. Equipment according to claim 17 or claim 21, further comprising a signalling circuit for signalling a routing request signal, indicating the identity of a mobile terminal called on said communications link, to a store and for receiving a reply signal, said equipment selecting either said first or said second channel in dependence upon said reply signal.

25. Equipment according to claim 17 or claim 21, in which said first communication channel comprises a dedicated ground network interconnecting said earth station and said gateway equipment.

26. Equipment according to claim 25, in which said ground network comprises a leased line.

27. Equipment according to claim 25, in which said ground network comprises a virtual circuit provided over a shared line.

28. Equipment according to claim 17 or claim 21, in which said second communications channel comprises an international public switched network.

29. A method of connecting a mobile terminal, via a satellite and a satellite earth station, with a terrestrial communications link, comprising selecting one of two alternative routes between the earth station and the communications link depending on whether the mobile terminal is of first or second status.

30. A method of connecting a mobile terminal, via a satellite and a satellite earth station, with a terrestrial communications link, comprising setting up a route through a terrestrial long-distance network between the earth station and the communications link, and ensuring that, where possible, said route excludes satellite links.

31. A satellite mobile communications system which defines user local areas, and denies access to a user outside his area.

32. Satellite system routing equipment for interconnecting a mobile terminal satellite communications system with a terrestrial communications link, said equipment comprising routing means for selectively interconnecting said communications link with one of first and second communications channels, either of said channels connecting to said mobile terminal via a communications satellite and an earth station, a first of said channels connecting via the public switched telecommunications network and a second of said channels connecting via a satellite system ground network.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report) -52-

Application number
GB 9423950.6

Relevant Technical Fields

(i) UK Cl (Ed.N) H4L (LDRR, LDRSX)

(ii) Int Cl (Ed.6) H04B 7/185

Search Examiner
MR N HALL

Date of completion of Search
4 JANUARY 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ON-LINE: WPI

Documents considered relevant following a search in respect of Claims :-
1-29

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	EP 0536921 A1 (SPACE SYSTEMS)	

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).